

A METHOD OF TRANSPORTING FINGERLING SHAD

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AS PART of an extensive research program now being conducted with shad at the Beaufort, North Carolina, Laboratory of the Fish and Wildlife Service, methods of transporting shad in various age and size groups are being investigated.

It must be pointed out that shad fry have been moved successfully in milk cans for very great distances. Stone (1874) transported 35,000 shad fry by rail from Castleton on the Hudson River to Tehama on the Sacramento River. This shipment was managed very painstakingly, for it was deemed necessary to give each can a change of water every 2 hours depending upon the availability of fresh water. Stone and his assistants conducted a very commendable shad movement, displaying great resourcefulness throughout the trip in acquiring fresh water and in holding the water at the desired temperatures. As a result of their success, the progeny of the fry that they introduced have established an extensive shad run in the Sacramento River and other Pacific Coast streams.

The work of Hollis (1948) and Leach (1925) indicates that fingerling shad are extremely delicate and susceptible to a high rate of mortality when handled. No evidence has been found to show that fingerling shad--unlike the fry--have ever been moved for any distance successfully.

Recently it became necessary that we have live shad at the Beaufort Laboratory for physiological and other studies being conducted by members of the staff and guest investigators. Fingerling shad (*Alosa sapidissima*) were available 300 miles away, at the U. S. Fish-Cultural Station at Orangeburg, South Carolina, where they had been reared originally for a juvenile tagging experiment.

Before the experiments got under way, a pond near the laboratory was placed in readiness to retain the young shad. The pond is 50 feet long and 35 feet wide and has a maximum of 2 feet of water on the lower side. Five tons of gravel were spread on the bottom. Fertilizer and *Chlorella* were added in an effort to condition the water and establish a food chain for the shad.

The following account describes the equipment and methods employed in the three shipments of fingerling shad from Orangeburg, South Carolina, to Beaufort, North Carolina. Every known precaution was taken with the first shipment, but it was unsuccessful. The second and third shipments were planned even more carefully and were highly successful.

EQUIPMENT

A wooden transporting tank was built at the Beaufort Laboratory. The plans used were those of a University of Washington Standard Transportation Tank. Constructed of juniper and marine plywood, the tank has these inside dimensions: length, 51-3/4 inches; breadth, 29-1/2 inches; depth, 30 inches.

The base of the tank extends beyond one end to serve as a base for the small gasoline engine that provides aeration. Water is pumped from the bottom of the tank into two pipes which extend along the sides above the water level. Throughout their lengths, the pipes are perforated to allow small streams of water to be pumped back into the tank from the top.

The tank was given two coats of thin white paint on the inside to protect the

plywood from the water and one coat of grey deck paint on the outside. When the paint was dry, the tank was filled with water for a period of seasoning.

TRANSPORTATION

Mr. Reginald E. Willis, a mechanic employed by the Fish and Wildlife Service, accompanied me on all three trips. Mr. C. E. Atkinson, Director of the Laboratory, accompanied us on the second trip.

Experiment 1

When the pond and tank were completed, the latter was placed on a 3/4-ton pick-up truck. The journey to Orangeburg, South Carolina, got under way on the morning of February 13, 1950.

When we arrived at the hatchery, we surveyed the small pond in which the shad were being held. Mr. James W. McPhail, the superintendent, did not know the exact number of shad, as they had not been seen for some time.

At 8 o'clock the next morning, we started draining the pond slowly. We went to the end opposite the spillway and sprinkled water on the surface to scare the shad toward the spillway.

Before the fish were seined, six tubs, each two-thirds full of water, were placed on the beach near the spillway. The first haul with the seine produced about 80 fish. Two men held the seine 8 to 10 inches below the surface so that we could see the shad and determine their size and approximate number. During this time, care was taken not to bring the fish completely out of the water. As soon as the net was lifted, a tub was floated under it and the fish were dumped in very quickly. A very few scales were seen in the tub after the first haul. The same procedure was followed with the second haul, when approximately 200 fish were seined. About 250 fish were caught in the third haul. This time we dipped the shad from the seine with a bucket. In the fourth and final haul, 100 shad were removed.

Immediately after each haul, a net was placed over the newly filled tub. The tub was then placed on a truck, taken to a point 100 yards distant, and set under a continuous stream of water. From the time the first tub was placed under the trough until the fish were loaded into the tank on the truck, 1-1/2 hours elapsed.

We decided to take approximately half of the fish to Beaufort on the first trip. This meant that the fish in one of the heavily loaded tubs and in one of the lightly loaded tubs would be taken. To get a count, the fish were dipped with a hand net from the tub to a bucket of water. The average dip, made very rapidly, contained three fish. Only 50 fish were dipped to a bucket, and these fish were immediately placed in the transporting tank. The total number of fish loaded was 376. The contents of the other two tubs were released in a concrete pool by placing the tubs in the water and letting the fish swim out. We planned to pick up all these fish three days later if the first trip was successful.

When the fish were loaded, the temperature of the water in the tank, which had been filled with 200 gallons from the hatchery fresh-water system, was 16.5° C.

At 11 o'clock in the morning of February 14, we left Orangeburg with the 376 fingerling shad.

The water sloshing from one end of the tank to the other made the truck difficult to handle and maneuver, and this may have been an adverse factor in the transfer of the shad.

Mortalities were first noticed at 12 o'clock noon (table 1). The water taken on at the Orangeburg Station was stained. It was impossible to determine the exact number of dead shad. Prior to this trip, we had not installed a trap door in the cover of the tank. To take the water temperature or see the bottom of the tank, it was necessary to remove the cover, which was secured by six wing nuts.

At 5 p.m., the temperature had risen to 19.5° C., a probable factor in the failure of this experiment. As it started to rain at this time, we put a tarpaulin over the back of the truck to protect the engine from drowning. It is possible

that the accumulation of fumes from the engine also contributed to our failure in this shipment.

Immediately after our arrival at Beaufort, the tank was drained enough for the bottom to be visible. All 376 shad were dead, lying on the bottom at the forward end.

Modification of Transfer Methods

After the first trip had been made, many faults could be found with the equipment and methods. Even though fingerling shad were presumed to be difficult to handle, it was believed that the faults of the methods and equipment could be remedied so that the shad would at least have a better chance to survive the 300-mile journey.

In the first place, it was believed that the tremendous surge of water in the tank was seriously detrimental. Furthermore, there was a strong feeling that the continual operation of the pump produced a spray too strong for the fish to withstand. Then too, there was conceived the idea that perhaps shad could be transported better in sea water than in fresh water.

It was decided that we should transport the next load of shad in water of 1.018 specific gravity, as Leach stated that this was quite good for the holding of shad. It was calculated that 137.5 gallons of sea water from Beaufort Harbor to 62.5 gallons of fresh water would give a specific gravity of approximately 1.018. More than 137.5 gallons of sea water was carried to Orangeburg to allow for possible loss enroute.

After much thought had been given to the possible lethal factors, horizontal baffle boards were installed to prevent the surge of water. Two boards, each 11-1/4 inches wide, were fastened along the sidewalls of the tank, 1-1/2 inches below the surface of the water. A board

TABLE 1.--Record of first shipment of fingerling shad

Time	Temperature (C.) of water	Tank	
		Pump operation	Remarks
A.M. 11:00	16.5°	Continuous	Left Orangeburg with 376 live fish. Fresh water.
12:00	17.0°	Continuous	30 to 50 dead.
P.M. 1:00	18.0°	Continuous	Mortality about the same.
3:00	19.0°	Continuous	Increase in mortality difficult to esti- mate.
5:00	19.5°	Continuous	Water thick and cloudy with mucus.
8:45	19.5°	Continuous	Tarpaulin erected. Arrived at Beaufort. All fish dead.

15 inches wide was placed in the center of the tank, 11 inches from the bottom. The tank was placed on the truck, filled, and given a test run. No water surge could be felt in the truck, and there was no splash over the top of the tank (from which the cover had been removed).

A trap door was installed in the cover so that the temperature and bottom could be checked more regularly. A small roof was constructed over the engine to eliminate the necessity of a tarpaulin and possible mortality from engine fumes. A tank of compressed oxygen with an adapter for two rubber hoses was placed on the truck.

Experiment 2

With the improvements noted, we arrived in Orangeburg and on the morning of February 17 prepared to remove half the shad that had been left in the concrete pool.

The transporting tank was drained to 137.5 gallons. The temperature of that water was 9.5° C. To that water was added 62.5 gallons of fresh water from the pool in which the shad were living. The temperature of this water was 12.5° C. The temperature of the water when mixed was 11° C., but it dropped later as the water became more thoroughly mixed by the pump.

Because this was a cold day, the temperature stayed down during the entire trip.

The shad were seined and then transferred from the seine to the tank by bucket rather than by dip net. One hundred and three shad were put in the tank, and 10 shad were put in each of two 10-gallon milk cans filled with fresh water. These two cans were being used to test various methods of transporting the shad. One milk can was placed in a larger container filled with ice, and both milk cans were supplied with a very small amount of oxygen.

As shown in table 2, the pump on the tank was operated only 10 minutes in every hour after the first 95 minutes of the trip. At the end of each 100 miles, the entire top of the tank was removed and one top baffle was taken out. By doing this, we could examine the fish swimming near the bottom of the tank. These fish appeared healthy during the entire trip.

Eight of the shad in the iced can died when the temperature dropped to 2°C ., and the other two shad in that can died by the time the temperature reached 0.5°C . The only explanation that can be offered for the death of two fish in the second can is that they were subjected to too much oxygen.

Two inches of sea water had been added to the receiving pond to eliminate the necessity of putting the shad directly into fresh water. Fifteen gallons of water was bailed from the tank, and water from the pond was pumped gradually to the original surface mark in the tank to balance the salinity and temperatures and prevent possible shock. This was repeated three times, after which the temperature of the water in the tank was 10.5°C ., the temperature of the pond water. Can No. 1 was given the same treatment. When the temperatures balanced, the shad were dipped in buckets from the tank to the pond. The fish swam off vigorously.

Experiment 3

Because the second trip had been so successful, it was decided that the third

would be conducted in the same manner except for two changes in the cans filled with fresh water: oxygen would not be used for Can No. 1, and ice would not be used for Can No. 2.

On the morning of February 21, 139 shad, the remainder of the lot, were seined from the pool at Orangeburg and dipped with buckets into the tank and cans. Ten shad were put into each of the two cans, and 119 shad were put into the tank. The temperature of the sea water was 8.2°C ., and the temperature of the pool water was 11.2°C . When the water was mixed in the tank, the temperature was 9.8°C . and its specific gravity (effected as in the second experiment) was 1.018. The temperature of the water in both cans was 10°C . Oxygen was started in Can No. 2.

As summarized in table 3, the same success with the tank was attained in the third experiment as in the second. The pump was operated at the same intervals, and the temperature remained fairly constant.

In Can No. 1 (no oxygen) and Can No. 2 (oxygen) the temperature rose considerably higher than in the tank. Possibly this accounts for the loss of one fish in Can No. 1, and possibly the combination of the high temperature and an oversupply of oxygen accounts for the loss of two fish in Can No. 2.

As the temperature of the pond water was 14°C . and that of the water in the cans was so close (No. 1, 14.8°C .; No. 2, 14°C .), the cans were tilted in the pond and the fish allowed to swim out. They swam away, apparently in good condition.

The temperature and salinity in the transporting tank were balanced with the pond water before the fish were transferred. Once in the pond, they appeared even more active than those transported in the second trip.

SUMMARY

Three hundred and seventy-six fingerling shad were transported a distance of 300 miles in a live tank filled with fresh water. The temperature ranged from 16.5° to 19.5°C . The surge of water

TABLE 2.--Record of second shipment of fingerling shad.

Time	Tank		Remarks	Can No. 1			Can No. 2 (Iced)		
	Temperature (C.) of water	Pump operation		Temperature (C.) of water	Oxygen	Remarks	Temperature (C.) of water	Oxygen	Remarks
a.m.									
9:10	11.0°	Continuous	Left Orangeburg with 103 live fish. Specific gravity of water, 1.018.	10.5°	On	10 live fish.	10.5°	On	Ice added. 10 live fish.
9:53	10.0°	Continuous		10.0°	On	All living.	2.0°	On	8 dead; 2 weak.
10:40	9.9°	Continuous		9.5°	On	All living; 3 on their backs.	1.0°	On	9 dead.
10:45	-	Off		-	-	-	-	-	-
11:15	9.9°	-		8.5°	On	All living.	0.5°	On	All dead. End of temperature recording.
11:50	9.9°	10 minutes	Top off for inspection. All living.	8.0°	Off	All living.	-	Off	-
p.m.									
12:45	9.5°	10 minutes		8.0°	-	1 dead.	-	-	-
1:50	9.5°	10 minutes		8.0°	-	1 dead; 1 weak.	-	-	-
3:05	9.2°	10 minutes		8.6°	-	1 dead; 1 weak.	-	-	-
4:20	9.0°	10 minutes	Top off for inspection. All living.	9.0°	On	2 dead.	-	-	-
5:00	-	-		-	Off	-	-	-	-
5:30	8.7°	10 minutes	Arrived at Beaufort.	8.3°	-	2 dead.	-	-	-
6:55	7.7°	10 minutes	Top off and baffles out for unloading. All living.	7.2°	-	8 living; 2 dead.	1.0°	-	All dead.

TABLE 3.--Record of third shipment of fingerling shad

Time	Tank		Can No. 1			Can No. 2		
	Temperature (C.) of water	Pump operation	Remarks	Temperature (C.) of water	Oxygen	Remarks	Temperature (C.) of water	Oxygen
a.m.								
8:55	9.8°	Continuous	Left Orangeburg with 119 live fish. Specific gravity of water, 1.018.	10.0°	Off	10 live fish. Fresh water.	10.0°	On
9:34	9.0°	Off	-	9.8°	-	All living.	9.8°	On
10:17	9.5°	-	-	10.3°	-	All living.	10.3°	On
10:48	9.5°	10 minutes	-	11.1°	-	All living.	11.5°	On
11:30	9.5°	-	Cover off for inspection. All living.	12.0°	-	All living.	12.2°	On
p.m.								
12:14	9.9°	-	-	13.0°	-	All living.	12.5°	On
1:30	10.2°	10 minutes	-	14.5°	-	All living. Good condition.	14.8°	Off
2:35	10.5°	10 minutes	-	15.5°	-	All living.	16.5°	-
3:30	10.8°	10 minutes	Cover off for inspection. All living.	16.0°	-	1 fish on back at top.	16.5°	On
4:50	11.0°	10 minutes	-	15.8°	-	1 dead.	15.8°	On
6:05	11.0°	10 minutes	Arrived at Beaufort. Top off and baffles out for unloading. All living.	14.8°	-	1 dead.	14.0°	Off

10 live fish. Fresh water.

All living.

All living.

All living.

All living.

All living.

All living.

All living.

Fish at top of can and moving spasmodically. Fish look better.

All but 1 at bottom.

2 fish at bottom look very weak.

2 dead.

2 dead.

in the tank was very great, and the aeration unit was allowed to run continuously. All the shad were dead at the bottom of the tank upon arrival at their destination.

On a second attempt, 123 shad were transported: 103 in the tank filled with water having a specific gravity of 1.018, 10 in a milk can of fresh water supplied with oxygen, and 10 in a milk can of fresh water packed in ice and supplied with oxygen. The tank was equipped with baffles, and the temperature range was from 7.7° to 11° C. Aeration was applied 10 minutes in every hour. The temperature in the can without ice ranged from 7.2° to 10.5° C. Eight of the fish in the iced can died when the temperature went down to 2° C. No shad were brought back alive in the iced can. Eight shad were transported alive in the can without ice, and 103 were transported alive in the tank.

On the third trip, 139 shad were transported: 119 in the tank and 10 in each milk can. The procedure used with the tank during the second trip was repeated, and the temperature ranged from 9° to 11° C. All 119 shad in the tank were alive when they arrived. The temperature in the two cans ranged from 9.8° to 16.5° C. The higher temperature seemed to affect the fish, as they did not appear to be nearly so vigorous as those in the tank. Furthermore, the smallest amount of oxygen that could be released into Can No. 2 made the fish appear unhealthy. It is believed that the splash in the milk cans

produced sufficient oxygen. Two shad in the can supplied with oxygen (No. 2) died, and one shad in Can No. 1 died.

We think that factors which certainly contributed to the success of the second and third trips were the addition of the baffles and the decrease in time during which the pump was run. We also believe that shad remain more vigorous and are not so susceptible to mortality if transported in at least part sea water. We have not proved this, however. Further, it is likely that the cool days on which the second and third lots were transported were beneficial to the vitality of the shad by preventing high water temperatures.

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